IoT-Based Wireless EV Charging System for Electric Vehicle

By SHRUTI PINGALE

IoT-Based Wireless EV Charging System for Electric Vehicle

First A. Shruti Pingale, Second B. Yadnesh Kotkar, Third C. Atharva Kusurkar

Abstract* - *The automobile industry has shown that electric vehicles are socially advantageous; nevertheless, wireless charging would be even more advantageous. Wireless power transmission (WPT) is expected to generate $5 billion in revenue in 2023, according to a new market study, and this figure might reach $30 billion over the following 15 years. A smart and useful infrastructure for EV charging is required, since the popularity of electric vehicles (EVs) has grown. Physical connection limitations, possible risks, and scalability problems plague traditional cable charging systems. To address these issues, this work presents a unique method for wireless EV charging by utilizing the capabilities of the Internet of Things (IoT) and the ideas of inductive power transfer (IPT). The three main components of the suggested system are the power supply unit, the charging station, and the electric vehicle (EV). The main source of electricity is the power supply unit. It creates a high-frequency AC signal by converting grid-supplied AC electricity. Integrated power coils in the charging station convey this signal. To ensure a successful transfer of electricity to the electric car, the charging station is equipped with a variety of receiving coils that are strategically positioned on the ground. Furthermore, the charging station's Internet of Things features allow for easy control and communication between the EV, charging station, and power supply unit. A receiving coil transports the supplied power to the electric vehicle (EV).

The incoming electricity is subsequently transformed into DC power using a voltage regulator and rectifier. The IoT capabilities of the EV enable real-time monitoring of the charging process and provide essential data regarding energy use, battery health, and charging status. By enabling optimal charging patterns, load balancing, and demand response, this real-time data monitoring and analysis helps to maximize the use of energy resources and lessen grid stress. This wireless EV charging system, which combines IPT and IoT technologies, offers a promising path toward an efficient, flexible, and user-friendly EV charging infrastructure.

Keywords: Wireless Power Transmission, Inductive Power Transfer, IOT, EV.

I. Introduction

Transportation with automobiles has been around for a while. Internal combustion engines power these cars. As the number of cars rises, internal combustion engines (IC engines) contribute to environmental pollution and a decrease in the use of fossil fuels. Fuel efficiency and emissions are being reduced by new developments in the vehicle sector. Hybrid vehicles cut emissions while maintaining engine performance by combining internal combustion engines and electric motors. Clean, green energy that emits no emissions will be prioritized in the future. The development and production of electric vehicles have attracted a lot of industry attention. Batteries have three main drawbacks: they are expensive, have a short range, and require a long time to charge. Customers are constantly looking for ways to make travel more efficient. Consequently, all gas stations now have charging systems that are connected. The limitations of wired charging include things like socket locations, distance between charging stations, limited cable lengths, and the requirement to move the car in order to connect to the charger. Electric car wireless charging options can aid in resolving these problems. Systems may be installed anywhere, including residences, parking lots, and garages, and this enables flexible and hassle-free charging.

Because they don't require wires or physical contact, Wireless Power Transfer (WPT) systems—especially those that use Wireless Inductive Power Transfer (IPT)—offer a number of benefits, including increased reliability, ease of use, safety, and lower maintenance costs.

These benefits make WPT systems appropriate for use in a variety of industries, including biomedical implants, textiles, space technology, mobile phones, and military applications. They are also appropriate for use in electric cars. It becomes vital in this situation to consider the idea of a wireless charger made especially for electric cars. In order to minimize stress on the electrical grid, this type of charger would use electromagnetic induction for connection and functioning. Nearly a century ago, Nikola Tesla first proposed inductive power transfer without a magnetic core, with the goal of wirelessly transmitting mains power across long distances. Ever since, medical equipment has found use for low-powered, closely connected wireless charging, and commercial goods that allow portable gadgets to be charged wirelessly using charging mats or pads are now frequently available.

Systems for wireless inductive power transfer are generally divided into two groups according to their range: systems that are medium to long range and can be used in personal area networks, and systems that are short range and usually cover a distance of approximately 5 inches. The main area of interest for this research is intermediate wireless transfer capability.

The focus of this study is on inductive coupling with matched resonance frequency, which highlights important aspects of effective wireless power transfer such as coil quality factor, resonance frequency alignment, link efficiency, and impedance matching. Non-radiative magnetic coupling is also investigated as a way to lower energy consumption and increase the suitability of WPT systems for medium-to long distance transmission.

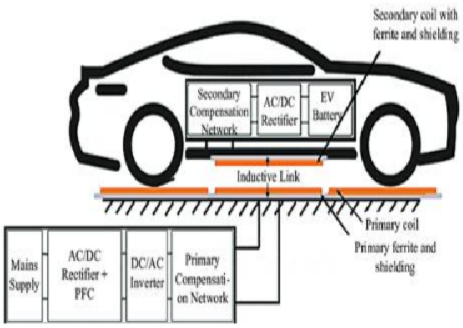

Fig 1. Prototype of wireless charging system.

Table1: Wireless Power Techniques

Techniques	Advantages	Disadvantages
Inductive coupling	Simple, safe, and high transfer efficiency in short distances.	Short transmission distance needs accurate alignment.
Magnetic resonance coupling	Long transmission distance, no radiation.	Difficult to adjust the resonant frequency for multiple devices
Electromagnetic radiation	Very high transmission efficiency over a long distance.	Produces radiation and needs a line of sight.

II. PAPER TITLE

IoT-Based Wireless EV Charging System for Electric Vehicle.

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IV. FOOTNOTES

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V. METHODOLOGY

The technology of wireless charging is one that is growing quickly and has attracted a lot of attention lately. Monitoring the charging process to guarantee effective and secure charging is one of the difficulties with wireless charging. The ESP32 module is a well-liked option for tracking wireless charging stations due to its low power consumption and wireless capabilities. We go over some of the most current research on ESP32-based wireless charging station monitoring in this overview of the literature.

Research indicates that using the ESP32 module as a foundation for monitoring wireless charging stations is dependable and effective. To guarantee effective and secure charging, the ESP32 module offers real-time monitoring, data collecting, and feedback to the user. In order to maximise the functionality and performance of ESP32-based wireless charging stations and to investigate the range of possible uses for them, more study is required.

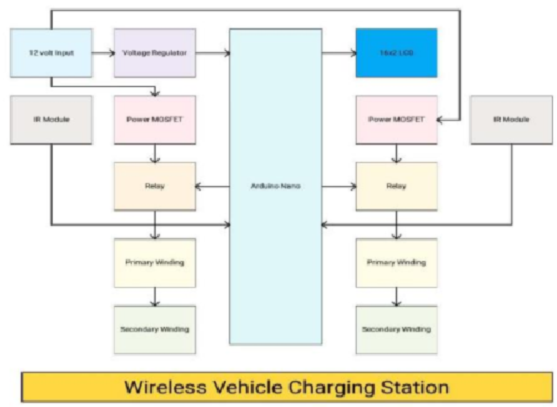

Fig 2. Block Diagram of the Proposed System

The block diagram [2] of an IoT-Based Wireless Vehicle Charging Station delineates the interconnected system components and their collaborative functioning. At the core of this setup lies the ESP32 Microcontroller, serving as the central control unit. This controller manages diverse operations such as communication with the app control interface, coordination of the charging process, interaction with various sensors and detectors, and implementation of power-saving measures.

The charging system comprises Dual Spot Charging, facilitating the simultaneous wireless charging of two electric vehicles. This process is enabled through Inductive Power Coils, ensuring efficient energy transfer. The MOSFET (IRZ44N) regulates and controls the power flow, ensuring the safety and efficiency of the charging process. Interfacing with the app control interface, users can seamlessly manage and monitor the charging process via a mobile application. Commands initiated through the app interface are processed by the ESP32 controller, enabling actions like initiating or ceasing the charging process. Sensors and detectors integrated into the system include an IR Sensor responsible for vehicle detection and positioning, enabling automated charging when a vehicle is parked over the charging spot.

The Auto Detection System identifies electric vehicles and triggers the initiation of the charging process automatically upon detection. Additionally, the system incorporates voltage regulation using a Voltage Regulator (7805) for stable voltage supply and energy-saving components to optimize power consumption. A Storage Battery (Lead Acid) acts as a backup power source, ensuring uninterrupted service in case of power failure or emergencies. Display functionalities are facilitated by a 16x2 LCD Display, providing real-time visual feedback on the charging status Together, these components and their collaborative functioning, orchestrated by the ESP32 controller, create a robust and efficient wireless charging infrastructure for electric vehicles, focusing on user convenience, safety, and energy efficiency.

VI. WIRELESS CHARGING SYSTEM ARCHITECTURE

Figure 3 illustrates the charging system, which includes many components. An alternating current (AC) supply is utilized to deliver high voltage.

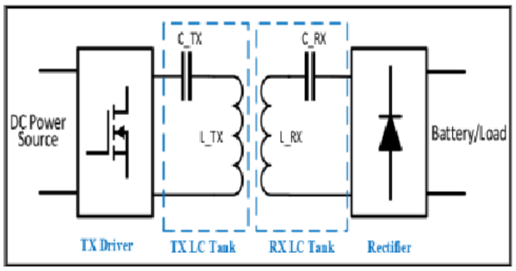

Figure 3.1: Circuit Model

A frequency converter (HF) converts low frequencies to high frequencies. This output is connected to the transmission coil (TX). The receiving coil (RX) is connected using resonant coupling. The output is converted to rectified DC via an AC-DC converter and used to charge the battery, which serves as the load. Magnetic resonators are the coils utilized in the wireless power transmission project. First, an HF Converter is used to feed a fast-oscillating current to a coil at a certain resonant frequency. To create a magnetic field around a transmission coil, tune a reception coil to the same resonant frequency as the source. This will couple the resonating magnetic field into an electrical current within the reception coil, known as the coupled magnetic response. Power can be sent to a load for battery charging. This electricity can be spread between different loads.
Figure 3 illustrates the fundamental circuit model of the WPT system, which is linked in a series-to-series topology. Given the system's complexity, the simplified equivalent network model is straightforward to assess. The circuit has main and secondary windings (L1 and L2, respectively). R1, C1 on the primary side, and R2, C2 on the secondary side. The components are linear and passive in nature.
The RLC circuit has the property of resonance. LC values may be modified to provide a resonant frequency ranging from 10 to 30 kHz. The current through the primary coil I1 depends on the input voltage V and the secondary coil's total impedance as viewed by the primary.

The total impedance(Ztotal) of the circuit is given by,

$$Ztotal = Requiv + j(XL - XC) \qquad (1)$$

$$Requiv = R1 + R2 \qquad (2)$$

$$XL = \omega 0(L1 + L2) \qquad (3)$$

$$XC = \frac{1}{\omega 0}(C1 + C2) \qquad (4)$$

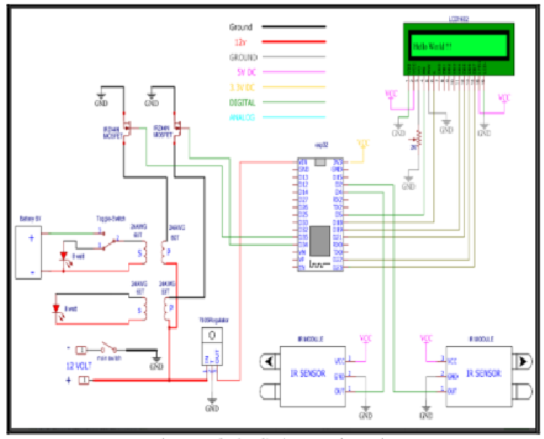

Figure 3.2: Schematic Diagram

Figure 3.2 shows the circuit diagram of an electric vehicle charging system. The main part or the heart of the system is the microcontroller which controls the functions of the devices connected according to the requirement. Using the Arduino uno processor the proposed system is implemented with programming written in Embedded C. The figure shows the different sensors used in the system.

Current sensor is used to measure the amount of current in a wire and generates a signal which is directly proportional to the current. The output signal is used to display the measured current using an ammeter or can be utilized for further analysis. Another important sensor is the Voltage Sensor which is mainly used to convert voltage measured into a physical signal and it is directly proportional to the voltage. Connection V is a physical signal port that outputs the measurement result.

The specialty is, it will measure the presence of a voltage without making metal contact. It is made of resistive voltage divider and integrated resistors, embedded in a casted resin, which has very low inductance. The whole arrangement is in the shape of zigzag, together with the resin permittivity which acts as a capacitance

Arduino uno, OLED and node MCU. The Arduino Uno microcontroller board developed based on Microchip ATmega328P, which has analog and digital input/output pins which can be connected to various extension boards and circuits.

VII. SOFTWARE SPECIFICATIONS

Arduino IDE:
Specifications:
Legacy IDE(1.8.X)- Arduino IDE(1.8.19).

Blynk App:
Specifications:
Blynk IOT App- Version:2.27.34

Blynk is a versatile mobile application designed to simplify the process of creating IoT (Internet of Things) projects by enabling users to control and monitor connected devices remotely.

Fig 4: App Implementation Screenshots

VIII. METHOD

Step 1: Set Up Blynk Account and Project
Step 2: Install Blynk Library in Arduino IDE
Step 3: Hardware Connection:
Step 4: Write Arduino Sketch:
Step 5: Define Blynk Authentication Token:
Step 6: Set Up Virtual Pins:
Step 7: Write Code for Interfacing with Blynk App:
Step 8: Test Communication with Blynk App
Step 9: Debug and Refinement:
Step 10: Documentation and Deployment:

IX. CONCLUSION

In conclusion, wireless charging eliminates the need for bulky wires and plug points, making it a straightforward and cutting-edge way to charge electric cars (EVs). demonstrating the effectiveness and usefulness of this technology, when the EV is parked above the wireless charger, electricity is created in the coil located at the bottom of the vehicle by mutual induction. Additionally, the expansion of wireless charging to allow charging while driving signifies a substantial development in EV charging capabilities, offering users increased convenience and flexibility. With implications for the future of transportation infrastructure, this evolution highlights the ongoing innovation in the field of wireless power transfer.

This report envisions future technologies like RFID tag payment and self-service entry and exit gates, highlighting the potential of wireless charging systems to change EV charging stations. The aforementioned enhancements are intended to optimize workflow, reduce traffic, and improve the overall user experience at charging stations. All things considered, the investigation of wireless charging technology in this work makes a significant addition to the area by providing insights into its effectiveness, use, and possible future advancements. As wireless charging develops further, it has the potential to completely disrupt not just the transportation sector but also a number of other industries, such as consumer electronics, healthcare, and industrial automation, thereby establishing itself as a game-change technological advancement.

X. FUTURE WORK

Dynamic charging solutions that are high-performing, safe, and reasonably priced will be at the vanguard of the electric vehicle (EV) revolution, which has the potential to completely change road transportation in the future. Finding the best mix of capacitive and inductive. Wireless Power Transfer (WPT) technologies is essential to this evolution and offers huge research opportunities in near-field coupler design and high-frequency power electronics. Additional research should be done in a few crucial areas: The long-term health effects of being exposed to weak electric and magnetic fields produced by dynamic charging devices require more research in order to ensure the safety of both users and onlookers.

To guarantee public safety and prevent mishaps, it is crucial to have strong systems for identifying live things and foreign items near WPT systems. To maximize the advantages of dynamic charging infrastructure, performance and cost-effectiveness must be optimized. This requires methods to identify the most efficient charger power levels and spacing. The development of methods for smoothly integrating WPT technology into traffic will be essential for its broad adoption and for making it possible for EVs to be conveniently charged while traveling.

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